HOUSE DRAINAGE.

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AS

CONSTRUCTED BY THE

DURHAM HOUSE DRAINAGE CO.

OF NEW YORK.

BY

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AS CONSTRUCTED BY THE DURHAM HOUSE DRAINAGE CO.

In reply to many inquiries on the subject, the following brief description of the "Durham System of House Drainage" is submitted.

The *chief features* of this system are *proper mechanical construction*, and *use of materials of superior quality*. The system of drain, soil, waste and air pipes, and the methods of ventilation and trapping are essentially the same as those generally practiced in the best works of "sanitary drainage", and all important features agree with standard rules and regulations of Boards of Health.

A well-planned and well-constructed system of house drainage should remove completely and as speedily as possible all waste matters from dwellings by *pipes thoroughly and tightly jointed*. The danger of infection arising from defective drainage and plumbing may be reduced to a minimum by a *proper system of trapping and ventilation*.

The following are the *essential features* of any thorough system of house drainage, viz: †

† See "House Drainage and Sanitary Plumbing," by W. P. Gerhard, C. E. Published by D. Van Nostrand, 2d Ed., 1884.

1. Extension of all soil and waste pipes through and above the roof.

2. Providing a fresh-air inlet in the drain at the foot of the soil and waste pipe system.

3. Trapping the main drain outside of the fresh-air inlet, in order entirely to exclude the sewer or cesspool gases from the house.

4. Providing each fixture, as near as possible to it with a suitable trap.

5. Providing vent pipes to such traps under fixtures as are liable to be emptied by siphonage.

These are what may be called *general maxims* and they are embodied in the following detailed

RULES ON HOUSE DRAINAGE:‡

All drain, soil, waste and air pipes inside of a dwelling (except the short branch wastes from fixtures) should be of iron.

The arrangement of soil and waste pipes must be as direct as possible, and long branch wastes under floors should be avoided everywhere.

Each stack should run up as straight as possible, avoiding offsets, which are objectionable.

None of the waste or vent pipes should be buried out of sight and rendered absolutely inaccessible. It is preferable to keep them in

‡ See "Hints on the Sewerage and Drainage of Dwellings," by Wm. P. Gerhard. Published by W. T. Comstock, N. Y., 1884.

sight, except on the parlor floor. The pubilc has long been accustomed and does not object to the running of steam pipes in plain sight, and there is no reason why soil pipes should not be treated in the same manner. Their outside can be painted, or, if desired, it can be gilt or bronzed, as is done with steam pipes. Where pipes must be placed in recesses or chaces in the walls, or in partitions, they should be covered with wooden panels, or boards, fastened with screws, so as to be easily removed, should an inspection of the plumbing become necessary.

The soil, waste and air pipe system should be thoroughly tight, not only water-tight, but air-tight as well. Hence, the pipes must be of thoroughly sound material, and all joints must be perfectly made.

The system must be amply ventilated, and should have no "dead ends." Each soil pipe, therefore, must extend at least full size from the cellar to and through the roof; waste pipes must also be extended, but should be enlarged just below the roof to 4 inches in diameter, to prevent obstructions of the pipe in winter through hoar frost.

Wherever practicable, soil and waste pipes should run along a heated flue, as this will assist in creating an upward draft in the ventilating pipes.

Soil, waste or vent pipe extensions may also, wherever convenient, run through a hot flue, terminating at least 2 feet above the top of the flue, but in no case shall vent pipes or air pipes be run only to a hot flue and stop there.

The extensions above the roof should, in all cases, be not less than 2 feet high, so as to be well exposed to air currents; if near a chimney top, they must terminate well below it. In any case, soil pipe mouths should be located as remote as possible from the ventilating shafts, chimney flues, or ventilating skylights.

The mouths of all pipes above the roof should be kept *wide open*. Return-bends are highly objectionable; ventilating caps clog up in winter time through hoar frost. None of the many patent ventilators are preferable to an open-mouthed pipe. To prevent obstructions of the pipe, insert into the top a copper mushroom-shaped wire basket (commonly called leader guard.)

Soil pipes should not be larger than four inches in diameter; vertical waste pipes for sinks or bowls, are generally 2 inches in diameter.

Each vertical line of air pipes must be at least 2 inches in diameter, increasing at the upper floors (in the case of high buildings) to 3 and even 4 inches diameter.

Each line of air pipe should extend as straight as possible up through the roof, where its mouth should be well exposed to the wind, and provided with a grating, screen or basket for protection. Air pipes may, however, branch into their soil pipe above the highest fixture, thus avoiding a large number of holes on the roof.

Each vertical line of air pipe must have the necessary fittings to connect the branch air pipes from traps to it. It is a mistake, fre-

quently made, to use inferior material (lighter pipes) for such air pipes. They must, invariably, carry more or less foul gases, their joints should, therefore, be as tight as those of soil and waste pipes.

Leader pipes, if inside the walls, must be of wrought iron, with thoroughly tight joints. If the leader opens at the top near attic windows, or near chimney flues or ventilating shafts, and if it is made of metal (galvanized iron or tin) and passes near windows of living or sleeping rooms, it must be trapped by a trap, with deep seal, located out of reach of the frost. Iron leaders with tight joints opening at the top remote from flues, or ventilaors, or windows, should not be trapped.

Rain water leaders should not be used as soil pipes nor soil pipes as leaders.

Areas, court yards and paved open spaces should be properly drained by a trapped waste pipe, the trap of which should, if possible, be located inside the cellar wall accessible for cleaning, and protected from the danger of freezing.

Each stack of soil or waste pipe must have fittings in proper position to receive the flow from the fixtures. It is not absolutely necessary that the fittings on vertical soil pipes should be Y branches; a Tee-branch, especially, if its flow line is shaped in a curve, will answer the purpose as well, and such is especially the case for small waste pipes joining the soil pipe.

The flow from all soil and waste pipes is col-

lected in the cellar, the aim always being to concentrate the system as much as possible. As a rule, it is better to connect the rain water leaders with the drain that carries the waste water of the household. In country residences where the rainfall is collected in a cistern, a separate system of pipes is required, and this is also the case, wherever the sewerage system of the city is the so-called "separate system."

The junction between upright soil, waste or leader pipes, and the horizontal drain, is of the greatest importance. The best support that could be given to it, is to build a brick pier under it, and to rest the weight of the upright pipe stack on it. Sometimes a strong wooden post is of service, though not making as substantial a job as a brick pier. The junction should be made with an elbow fitting of a large radius, or with Y-branches and 45° bends, in order to make the change in the direction of the flow as gradual as possible. A right angled connection must not be tolerated, as it is sure to cause accumulation of soil and create stoppages.

It is to be recommended to run the main cellar drain *in sight* along one of the foundation walls, or to carry it along the cellar ceiling suspended from the joists or iron beams by strong iron hangers.

Where there are fixtures in the cellar, the main drain must run below the floor, and in this case it is advisable not to bury it entirely out of sight. Cleaning hand-holes should be

provided at all junctions of branch drains with the main, also near or at bends, at the trap, and at the foot of vertical stacks. These hand-holes must be left accessible by building small man-holes provided around them with covers.

Many authorities require every drain below the cellar floor to be laid in a trench with concrete bottom and with brick walls, accessible throughout its entire length. This seems necessary only where inferior material is used, and where the workmanship is not first-class. With heavy iron pipes tested not only at the foundry, but also after being placed under the floor of a house (by the water or air pressure test), and with few well-made joints it is better to bury the drain pipes in concrete, leaving out places for access only wherever really needed.

For all horizontal or inclined drains the rule should be laid down, that no junction should be made at right angles, with Tees; 45° Y or 67½° Y-branches must be used. All changes from the straight line must be made with curves of a large radius. It is advisable to use near junctions, curves and traps, hand-holes giving ready access to the drain pipes in case of accidental or malicious stoppage.

The fall required for the main drain will depend upon its size; the latter should not exceed six inches in most cases. Where a building is unusually large, it is better to have two main drains, each six inches diameter, than one drain of nine inches. As a rule, however, four and five inch drains are ample for ordin

ary sizes of dwellings. Such a drain should, if possible have a fall of ½ inch to the foot, but a fall of ¼ inch to the foot is sufficient to carry along whatever ought only to enter such pipes.

Wherever such fall cannot be had, it is advisable to arrange a flush tank at or near the head of the house sewer, to be operated by hand at frequent intervals or else to discharge automatically.

If the main drain is trapped, as is advisable in most cases, the running trap of iron should be located just inside the cellar wall or else outside the house, in a man-hole. It should be located where it is not exposed to freezing.

In any case the trap must not be absolutely inaccessible, as it is possible that obstructions may occur at this point. The trap should, therefore, be provided with cleaning holes, closed air-tight with well-fitting covers. It is advisable to run into this trap a leader, so as to insure its occasional flushing at each rainfall.

To insure a full circulation of *fresh air* through the pipes, a fresh air pipe, of the full diameter of the iron drain, must run from just inside the trap to some point outside, well remote from windows, so as not to cause any objectionable smell, as it becomes at times—though seldom—an *outlet* instead of an inlet.

As soon as the main soil and drain pipe system is completed, its tightness should be tested by the water pressure test or by the peppermint test.

Another equally reliable test is the air pres

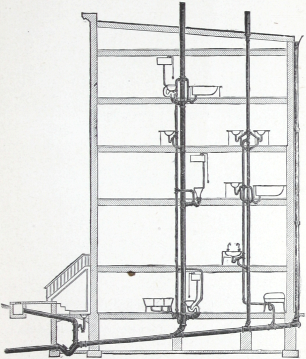


FIG. 1.

sure test by a force pump and a manometer. In this test every part of the pipe system is subjected to a *uniform* pressure, while in the water test the pressure increases with every foot of head of water, thereby often putting an unusually severe strain on the lower part of the pipe system.

The house drain should be of iron, to a point well beyond the foundation walls. Whether it should be continued any further with iron pipe or whether vitrified, well-glazed pipes may be used for the external sewerage, will depend entirely upon the character of the soil. For made ground, *heavy* iron pipe is decidedly to be preferred, but care must be taken to lay the pipes on a good solid foundation. It is also safer to run a drain of iron pipes, where it passes near a well, furnishing drinking water. Occasionally roots of trees cause considerable trouble with vitrified pipe, especially if the joints of the latter are poorly cemented. In such a case, iron pipes, with caulked joints, are preferable.

Figs. 1 and 2 represent sections through a city and a country dwelling, showing all drain, soil, waste and air pipes; also the fixtures and the mode of trapping them.

Fixtures should be concentrated as much as possible in vertical groups.

Fixtures should never be located in rooms without proper and ample ventilation.

It is preferable to locate water-closets and urinals in well-lighted apartments having windows to the outer air. This insures cleanli-

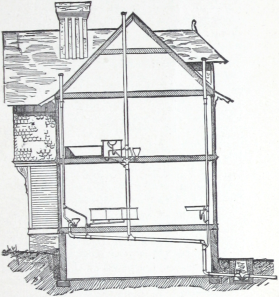


Fig. 2.

ness and prevents fouling of fixtures through improper use.

Each fixture should, wherever possible, discharge into the main soil or waste pipe independently. The branch wastes should in all cases be as short and direct as possible, and this will largely depend on a judicious planning and locating of fixtures by the architect. Waste pipes of lead should be of the following sizes:

For one wash-bowl	$1\frac{1}{4}$	inches diameter,
For a row of basins	$1\frac{1}{2}$	" "
For a bath-tub	$1\frac{1}{2}$	" "
For a row of bath-tubs, likely to be used at once	2	" "
For a pantry sink	$1\frac{1}{4}$	" "
For a kitchen sink	$1\frac{1}{2}$	" "
For a set of laundry trays	$1\frac{1}{2}$	" "
For a slop sink	$1\frac{1}{2}$–2	" "
For a urinal	$1\frac{1}{2}$	" "
For a row of urinals	$1\frac{1}{2}$–2	" "

The weight should be about 2 lbs. for $1\frac{1}{4}$ inch pipe, $2\frac{1}{2}$ lbs. for $1\frac{1}{2}$ inch pipe, and 3 lbs. for 2 inch pipe. All joints in lead pipe should be wiped solder joints, and no cup joints should be tolerated, except where local circumstances render the wiping of a joint impossible.

Where lead pipes join the wrought-iron pipe the following mode of connection is recommended: Lead waste pipes and lead branch air pipes from traps are connected by brass screw nipples, wiped to the lead pipe with solder, and screwed tightly with red lead and a wrench into the threaded opening of the fitting.

Each fixture connected to the soil or waste

pipe system, must be provided as near as possible to its outlet, with a suitable trap, secure against siphonage, back pressure, evaporation, etc. If lead traps are used, the weight of the lead should be equivalent to the weight of the lead pipe.

Overflow pipes are, as a rule, objectionable; the same is true of any waste pipe not in constant use.

Overflow pipes, if such are used for fixtures, must connect to the waste pipe on the inlet side of the trap or below its water level, or else they must discharge over a "safe."

Overflow pipes from water tanks should discharge into the gutter of the roof, or else empty over some sink in a lower story. Never should they have direct connection with any waste, soil, drain or vent pipe.

The water in all traps under any kind of plumbing fixture must be frequently changed.

Stagnation of water or air should be avoided, not only in the drains and vent pipes, but in the traps as well.

It is useful, and where cost is no objection, advisable to ventilate the house side of the traps and overflow pipes by a vent pipe, running into some *special* flue, constantly heated for such purpose. A draft is thus created from the room, through the fixtures, into the heated flue, and any gases given off at the house side of the water-seal may thus be effectually removed.

Drip pipes for safes under fixtures should not have any connection whatever with any soil or

waste pipe or drain. They should be collected in the basement or cellar and discharged over an open sink, so that any leakage may be at once apparent.

Refrigerator wastes must never be directly connected to any soil, waste or drain pipe. These wastes are very apt to become coated with slime and dirt in a short time; they frequently stop up, and are generally liable to become offensive, especially if the ice used is very impure.

The outlets of all "set" fixtures except water closets should be protected against obstruction or chokage by a fixed strainer.

Water closets, urinals and slop sinks or slop hoppers must not be supplied with flushing water directly from the main supply pipe. They should be flushed from small cisterns placed over each fixture or over each group of water closets or urinals.

In public buildings or public places it is preferable to make the flushing independent of the carelessness or forgetfulness of the user by arranging for automatic flushing either immediately after use of the fixture or else at fixed intervals.

Grease traps are to be recommended for kitchen and pantry sinks of large buildings, such as hotels, eating houses, cooking establishments, etc. For small households grease traps are unnecessary, and the waste pipes may be kept clean by occasional flushing with a concentrated solution of potash.

Openings in the cellar floor, connecting to

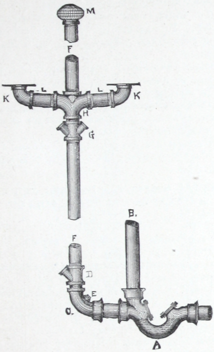


FIG. 3.

the house drain, are highly objectionable, unless trapped by some deep trap, the water seal of which is not easily lost through evaporation. In localities subject to back-water from tides a flap valve or ball valve may be required.

Better than either arrangement is a pipe, carried up from the main house-drain to the cellar floor, and closed tight by a plug screwed into the outlet of such pipe, which plug may be removed should it become necessary to carry off water from the cellar floor.

There should be as little plumbing in a building as possible, but what there is should be *perfect*.

SPECIAL FEATURES OF THE DURHAM SYSTEM OF HOUSE DRAINAGE.

CONSTRUCTION.

In a pamphlet describing his system, Mr. C. W. Durham, C. E., has truly said: "*Proper mechanical* construction must be the foundation of any good system of drainage." * * "By the use of wrought-iron pipes and screw-joints we construct a drainage apparatus within the building, which is gas and water-tight as regards the joints; rigid, yet elastic; entirely independent of walls or floors for support, and absolutely invulnerable. As a structure, it will last as long as any building will stand—*without any outlay for repairs*."

"When lengths are screwed together in a wrought-iron coupling, the joint is as strong as any other part of the pipe, and they will

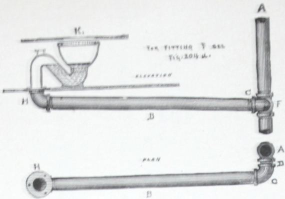


FIG. 4.

stand up vertically, from a solid base to the height of any building without lateral support."

"The result attained is a system of pipes which are independent of the building for support; which cannot be cracked or broken; and whose joints are permanently gas-tight beyond the shadow of a doubt."

The following illustrations,taken from the writer's book, "Hints on the Sewerage and Drainage of Dwellings", illustrate the chief features of construction. Fig 3. shows a soil pipe stack as constructed and erected by the Durham Company.

A is the running trap on the main house drain, with cleaning holes and a fresh-air pipe, B, on the house side of the water seal, carried to a point remote from windows, or to the street curb. C is the soil pipe elbow on which the whole straight soil pipe stack, FF, is erected independent of walls or partitions. E, is a plug in the soil pipe ell to remove any obstruction which may happen at this bend. D, is a 4"x2" Y branch for a sink waste, G a 4"x2" double Y branch for bath and bowl wastes; H, is a double cross with grade, and LL are, branches from water closets, which rest on the iron flanges KK.

Figs. 4, 5, 6 and 7 show the manner of supporting the water-closet, the chief plumbing fixture in a dwelling, directly from the soil pipe, independent of the floor, on special elbow fittings or water-closet flanges, KK. This is especially important for water-closets with trap above the floor, as in the common system

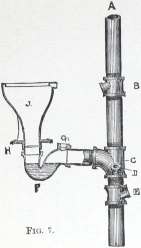
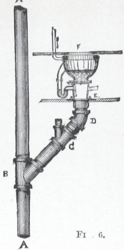


FIG. 7.



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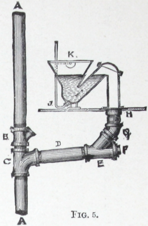


FIG. 5.

the joint at the floor is liable to open through shrinkage and settlement of floors or joists. Fig. 4 shows how closets at a distance from the soil pipe are supported on a cast-iron base, to which they are securely attached. This cast-iron base rests on the floor, but its waste pipe is connected to the soil pipe by a *flexible* joint. A settlement of the floor and a subsequent sinking of the cast-iron base, holding the water-closet, cannot loosen or open the joint at the soil pipe. Fig. 5 shows a water-closet with a trap above floor, supported on the branch from the soil pipe. Fig. 6 shows a trapless closet supported in the same manner. Fig. 7 shows the manner of supporting water-closets, requiring a trap *below* the floor.

The illustrations purposely show different fittings on the soil pipe, and different ways of running the branches from the soil pipe to the water-closet. From these sketches it is, furthermore, evident that any *good* form of water-closet can be used in connection with the Durham System. We advise in every case against the use of the ordinary "pan closet" as being an entirely unsanitary fixture which becomes extremely foul after some use.

Fig. 8 shows the manner in which the wrought-iron soil pipes, A, are screwed into the elbow fittings, D, which connect them with the underground drain, F, (the same fitting is shown in Fig. 3 at C.) It will be noticed that the change in the direction of the flow is effected with an easy curve. Fig. 9 illustrates the same junction between soil pipe and drain where the latter is of wrought-iron and carried

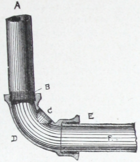


FIG. 8.

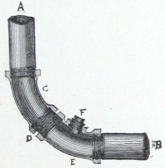


FIG. 9.

along the cellar wall. In both cases the construction provides for hand-holes closed by plugs for removal of accidental obstructions.

In the former case the whole weight of the vertical stack is supported on the soil pipe ell which must be securely set on a solid foundation of concrete or masonry. In the case of drains being carried along the cellar wall or near its ceiling, the vertical stack is supported at the junction with the horizontal drain by means of strong iron hangers or straps.

As the wrought-iron pipe is brought into the market in lengths up to 20 feet, the number of joints of each stack of soil or waste pipe is largely reduced. It is generally possible to *run from floor to floor without intermediate joints*, and this effects not only a saving in labor, but reduces the danger from imperfect joints.

MATERIALS.

For all soil, drain, waste, and vent pipes, and for leaders (conductors), in fact for all pipes above ground, the Durham System uses the asphalted standard *wrought-iron*, lap-welded steam pipes. The following is taken from the writer's book "Hints on the Drainage and Sewerage of Dwellings":

"Wrought-iron pipe is extensively manufactured by many "tube works" at the rolling mills, in lengths of about 20 feet. Bars of wrought-iron of a width corresponding to the circumference of the pipe, are bent up by means of powerful machines, while in a red heat to a circular shape. The ends of the smaller sizes (up to 2 inches diameter) are

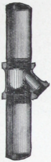


FIG. 10.

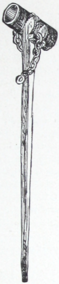


FIG. 11.

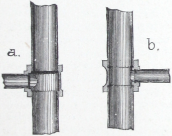


FIG. 16.

made to butt against each other, while the larger sizes lap over. The bars are then again highly heated and welded together, after which operation they are adjusted so as to be exactly circular in shape.

Before leaving the works, and while hot, the wrought-iron pipes are immersed in a tank, containing hot liquid asphalt, which coating of the pipes effectually protects their inside against corrosion. All standard wrought-iron pipes are tested at the works by hydraulic pressure up to 500 lbs. per square inch, and a guarantee of good durable material is thus secured.

The following table exhibits the size, thickness and weight of pipes, used for soil and vent pipes:

Size of Pipe.	Thickness of Pipe.	Wt. in lbs. per ft.
2"	.154 inches.	3.67
3"	.217 "	7.55
4"	.237 "	10.73
5"	.259 "	14.56
6"	.280 "	18.77

Such pipes are put together same as the steam pipes, with *screw joints*. (Fig. 10.)

The screw thread, cut externally on the pipe, is slightly tapering, and so is the internal thread cut on the fittings. It is customary for pipes from 2 to 6 inches diameter to have 8 screw threads per inch. These threads were formerly cut on a lathe, if done by machine work; if by hand, by the use of die-stocks. Within the last few years large hand and power pipe-cutting machines have been manufactured, which use dies and cutters, by which a large saving in

time may be effected. Instead of cutting internal threads of fittings in a lathe, they are now tapped by powerful tapping machines.

Wrought-iron pipes are screwed into couplings, or into fittings by means of pipe-chain tongs (see Fig. 11), on which a man can exert a powerful leverage, thus securing the great desideratum, *tight* joints.

In order to make up for imperfections in the threads of the pipe and fittings, a paste is used in making the joints, consisting of an equal mixture of white lead and linseed oil with red lead. This paste hardens after some time, and forms a tight packing in the screw-joint.

The pipes are cut to required lengths from exact measurements, in a power pipe-cutting and threading machine. Straight lengths of pipe are screwed together by means of wrought-iron couplings; for changes of direction, special fittings, such as elbows, T and Y branches are used, which will be described later."

For drains *underground* the Durham System uses heavy *cast-iron gas pipe*, with leaded joints. To quote from Mr. Durham's pamphlet:

"Lead joints and cast-iron drains are employed only for pipes in a *horizontal* position, in which there can be no *pulling* strains. All other joints are *screw* joints, made with wrought-iron pipe."

The company advises, in every case, against the use of earthen pipes under and inside of a dwelling house, and agrees entirely with the opinion of Capt. Douglas Galton, an experienced engineer, who says:

"The use of cast-iron for house drains, if the cast-iron is solid, sound and free from porosity, will prevent leakage and sub-soil tainting beneath the house, and will be as cheap as earthenware pipes in many cases." * * *
"Lead joints can only be made in a strong iron pipe, and the use of these joints is, to some extent, a guarantee of soundness, but every pipe should be carefully tested by water pressure, to see that there are no holes or flues."

The following is a brief description of the manufacture of such cast-iron pipes, and the manner of laying such pipes and making leaded joints, taken from the writer's above quoted book:

"Pipes of heavy cast-iron are generally manufactured in lengths of 12 feet, with a hub and spigot end. As regards the strength of such pipe, much will depend upon their manufacture. The metal used should be a re-melted pig-iron of homogeneous texture, free and easy flowing when poured into the mould; the fracture must show a dark gray color. Then again, great care and diligence must be bestowed upon the making and drying of the pipe moulds and cores; the loam and sand should be carefully chosen, in order to form smooth and substantial moulds.

It is now pretty well understood by all manufacturers of first-class cast-iron pipe that the pipes should be cast over end, in order to obtain a *uniform* thickness of shell, which is the great desideratum for all pipes. If cast in a lying or inclined position, the molten metal poured into the mould has a tendency to float the core and bend it upwards in the centre,

consequently the thickness of the shell will be much greater at the lower part of the pipe.

Experts disagree in regard to the position of the socket while casting. In England it is customary to cast heavy pipes with the socket downward. In such a position, it is claimed, the head of pressure of the fluid metal, equivalent to the length of pipe, will secure a strong socket, free from air bubbles or other defects. The top end will often be spongy, containing floating dirt, slag, scoriæ and air bubbles. Should this occur with the socket or the bell end of the pipe, it would render the socket weak and often worthless for caulking purposes, while the spigot end may be cut off if necessary. A large dead bead is often given to the spigot end of pipe, which is afterwards removed by cutting. In Germany, on the other hand, the custom prevails of casting pipes socket upwards. In the United States of America, the general practice is to cast all pipes from 3″ to 12″ diameters, socket upward, while larger sizes are always cast socket downward. There are, I believe, practical advantages, such as easier drawing and removing of patterns, which influence the American foundries to cast with socket upwards.

After being cast, all pipes should be carefully protected from sudden chills, the cooling should be gradual and slow, so as to avoid imperfections in the metal. After cooling off the pipes are carefully cleaned with steel wire brushes and scrupulously inspected.

All such pipes should be straight, truly cylindrical, of a uniform thickness, of a uniform and

homogeneous texture, of *perfect smooth surface*, free from flaws or other imperfections, and the spigot end should truly fit the hub of the pipe. The pipe must not be brittle, but must allow of ready cutting, chipping, drilling or threading.

The thickness of metal of cast-iron pipes, used for sewerage purposes, should be about as follows:

2 inch pipes	$\frac{5}{16}$	inches	thick.
3 " "	$\frac{5}{16}$	"	"
4 " "	$\frac{3}{8}$	"	"
5 " "	$\frac{7}{16}$	"	"
6 " "	$\frac{7}{16}$ or $\frac{1}{2}$	"	"

After a careful and thorough inspection, each pipe must be tested under pressure in a hydraulic testing machine. Whilst under such pressure, the whole length of the pipe should be repeatedly struck hard with a heavy hammer, in order to detect flaws or weak parts of the pipe shell. If the sound of the hammer striking the pipe metal is clear or bell like, it is a pretty sure indication of the absence of any of the above imperfections.

If it is thus made sure that the pipe is free from air bubbles, flaws, shrinkage-cracks, sand-holes, etc., the pipe must be coated in order to protect it againt corrosion. The best solution known for cast-iron pipes is Dr. Angus Smith's patent coal-tar varnish. After placing the pipes in an oven, they are heated so as to well open the pores, and the solution is likewise kept hot in a tank, care being taken that it does not get too great a consistency. The pipes are then immersed in a bath for about 15 or 20 minutes, then removed, when the surplus of varnish is allowed to drip off from the pipe.

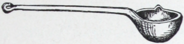


FIG. 12.

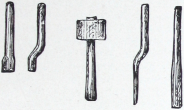


FIG. 13

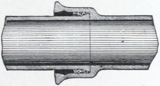


FIG. 14.

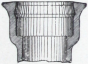


FIG. 15.

There should be only a thin smooth coating of varnish over the pipe. The pipes are now ready for use.

A word of caution seems appropriate in regard to failures of cast-iron pipes through rough handling during carting, or loading and unloading. Great care must be taken not to throw any pipes violently on the ground, nor to expose unloaded pipes to violent accidental blows. Owing to the brittleness of the material, cast-iron pipes often split or break off at the ends, and the split, although hardly perceptible on the outside, may continue longitudinally very far, which fact can only be detected by the pressure test,

In laying such cast-iron pipes, the spigot end of one pipe must be inserted as straight as possible and concentric into the hub end of the next pipe, care being taken before doing so that the pipe is clean and free from all dirt on its inside. A gasket of oakum or dry hemp is then inserted into the space between socket and spigot, and well rammed with a caulking tool. This gasket should fill about one-half of the depth of the hub, its object being to prevent any molten lead from flowing into the pipe at the joint, also to assist in tightening the joint.

A roll of good tough clay is placed around and pressed against the front of the pipe bell with an opening on top, where the two ends of the clay roll meet, large enough to admit of pouring in the lead. This clay ring prevents the escape of molten lead while running the joint.

The lead used for making pipe-joints should be soft and pure, without any admixture of tin, zinc or other metal. If hard or impure lead is used, the caulking operation strains the bells often so much as to burst or split them. The lead is melted in a large pot, kept on a furnace, It should be kept at a proper temperature in order to prevent too sudden cooling while pouring it. A large ladle (Fig 12), which must be capable of holding enough molten lead for one joint, is used to pour the lead into the space between spigot and bell. It is important that enough molten lead is poured in at one operation to quite fill the joint, for if the lead is not poured in a continuous stream the joint will not be perfect and homogeneous.

As soon as the socket is quite filled, the ring of clay can be removed and the lead allowed to cool, while the superfluous lead is cut off with a cold chisel. The lead naturally shrinks and would not, *per se*, make a tight joint, but requires a thorough setting up or caulking, which, is done first with a hammer and flat calking tool, next with a similar broader tool, with a slight curve corresponding to the size or radius of the pipe. Fig. 13 shows the caulking tools generally used.

Fig. 14 shows the calked joint in section, when finished. To insure a perfect joint the ring of lead should have an equal thickness all around. This thickness varies from $\frac{1}{4}$ to $\frac{3}{8}$ inch; the ring should have a depth of from $1\frac{1}{2}$ to 2 inches. The following table, showing the amount of lead required for a joint, may serve as a guide:

Diameter of Pipe in inches	Weight of Lead in lbs.	Depth of Lead in inches.
2	2	1½
3	2¾	1⅝
4	4	1¾
5	5½	1⅞
6	7	2

The lead must be left exposed so as to show the marks of the caulking tools. No paint, cement or putty should be used to fill the space in front of the caulking ring.

A proper caulking operation always puts a heavy strain on the sockets of the cast-iron pipe, and, in order to withstand it and prevent the bursting of bells, the latter should be designed very strong, with an extra thickness of metal at the end of the hub and at the point where the socket joins the pipe. The thickness of the hub should not be in direct proportion to the thickness of the pipe. This latter point is less thoroughly understood. The failure of common light plumbers' pipe is largely due to the fact that both the pipe shell and the thickness of the bell are reduced to a minimum. See Fig. A. While it may be possible to reduce the former slightly, wherever there is no heavy inside pressure or outside superincumbent weight, the latter should always be kept heavy enough to withstand a thorough caulking. See Fig. B.

In making lead joints in cast-iron pipes much, of course, depends upon the skill, sound judgment, experience, but above all, upon the honesty of the workman. Careless or dishonest

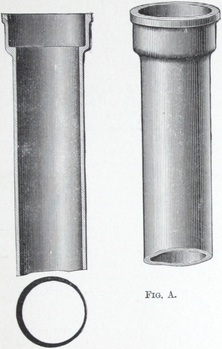


Fig. A.

PLUMBERS' SOIL PIPE.

mechanics are very apt to do the caulking of the lead imperfectly, to omit this operation entirely at the under side of the joint, which is difficult of access, and not so readily inspected. Perfect workmanship is absolutely essential in the case of iron drain pipes, not less than for water or gas mains.

Cast-iron drain pipes require a number of fittings, such as elbows, Y branches, traps, Tee branches, which are also cast with bells and connected to the pipes in the same manner as lengths of pipe are put together."

All the fittings used in the Durham System are special cast-iron fittings, made by the Company for its own use only. All such castings are carefully examined before use. They must be sound, smooth especially on the inside, without lumps, sand-holes, flaws or other scoriæ. To quote from Baldwin Latham, C. E.:

"There are faults, to which all articles made of cast-iron are liable, and which may escape observation even after the most careful scrutiny, and, in consequence, there will ever remain a certain degree of uncertainty as to the strength of iron castings, for there are numerous instances which may, more or less, affect the quality of the manufactured article, such as unequaled contraction in cooling, imperfections from latent flaws which may be concealed by a covering of sound metal, the brittle nature of the material, the presence of deleterious agents in the metal itself, all tending to render cast-iron more or less uncertain, and liable to fail without warning.

The proper admixture of the iron in the foun-

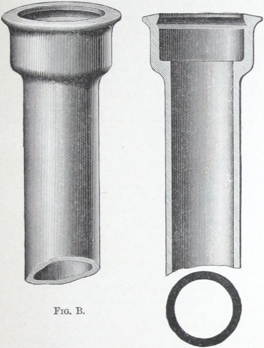


FIG. B.

HEAVY CAST-IRON DRAIN PIPE.

dry is one of considerable importance in order to ensure a perfect casting; for, as different varieties of iron have different points of fusion and varying rates of cooling, unless a proper admixture is ensured, the casting will have within itself an element tending to produce its own destruction, for, while some of the metal may be in a perfect fusion, other parts may be imperfectly fused, while again others may be burned: or in cooling, some of the metals may cool faster or slower than others, consequently the casting may be thus brought into a state of unequal tension, or, as it is technically termed, 'hide-bound,' when such slight influences as sudden change of temperature may lead to its instant destruction."

All fittings for cast and wrought iron pipes are carefully protected from rust by heating them and then dipping them into a bath of liquid asphalt.

All fittings for cast-iron pipes have hubs of great strength, shaped as shown in Fig 15, allowing the perfect caulking of the leaded joints.

It is evident that wrought-iron pipe requires a larger variety of elbows and other fittings, as the screw joint does not allow of the least deviation, such as may be made in the lead caulked joint.

Common steam-fittings are unfit for purposes of house drainage, as they leave interior depressions, when the pipe is screwed up, which would collect sewage. (See Fig. 16a). The fittings for wrought-iron pipes in the Durham System are tapped with a shoulder

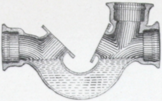
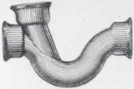


FIG. 17.



FIG, 18.

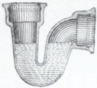


FIG. 19.

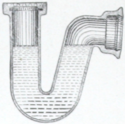


FIG. 20.

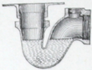


FIG 29.

(Fig.16b;)when the wrought-iron pipe is screwed home, its interior and that of the fitting form a practically continuous line. All pipes, however do not screw up equally far, and it happens that occasionally a small recess remains between the end of the pipe and the shoulder of the fitting. Such recess will be too small to be of any harm, at any rate it cannot collect more sewage matter than the inevitable recesses in cast-iron pipe at the point where the spigot end should touch the inside of socket. With *tight* joints, it seems that no serious harm need be apprehended from such unavoidable imperfections.

The following is a condensed list showing the varieties of fittings manufactured for use with the Durham System, a few of these being shown in sketches. The total number of special fittings amounts to about 200.

1. *For cast-iron pipe, 3", 4" and 6" diameter:*

Running traps (Figs. 17 and 18), leader traps with deep water seal (Fig. 19), and cellar-floor traps (Fig. 20).
90°, 60°, 45°, 22½°, 11¼°, 5⅝° ells, with one or two hubs. (Fig. 21).
Tee branches of all sizes. (Fig. 22).
Y branches, 45° (Fig. 23), all sizes, with or without hand-holes.
Y branches, 90° (Fig. 24), all sizes, with or without hand-holes.
Reducers of all sizes.

FIG. 21.

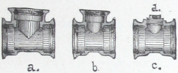


FIG. 22.

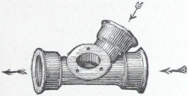


FIG. 23.

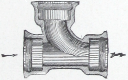


FIG. 24.

2. *For cast-iron pipe, with openings tapped for wrought-iron pipe.*

Soil pipe ells (Fig. 8 and Fig. 21h).
Sink ells, all sizes. (Fig. 21g).
Tees of all sizes. (Fig. 22c).
Cast and wrought-iron connection pieces or couplings. (See Fig. 25 *a, b, c*).

3. *For wrought-iron pipe, 2", 3", 4", 5" and 6" diameter:*

Plain ells, ells with ½" and with 1" grade, Three-way ells, 60", 45", 22½°, 11¼° and 5⅝° ells. (Fig. 26, *a, b, c, d, e, f*).
Water-closet ells (Fig. 26h), and water-closet flanges.
Plain Tees, graded Tees, all sizes (Fig. 27, *b, c*), water-closet Tees (Fig. 27a), crosses, with and without grade (Fig. 28a) increasers and reducers of all sizes, 45° and 67½° Y branches, in all sizes. (Fig. 27 *d* and *e*),
Water-closet traps (Fig. 29), yard drain traps, bushings, plugs, couplings, nipples, caps, union couplings and flange unions.

It has been repeatedly asserted that wrought-iron rusts quicker than cast-iron, if plain and entirely unprotected. This is true and well-known to every engineer, but it does not prevent engineers from using an otherwise excellent, and, in many respects and for many uses, superior material. All iron pipes used for sewerage purposes must be efficiently protected against corrosion, and such is done with cast-irôn pipes by coating them with coal-tar pitch, while wrought-iron pipes are dipped thoroughly heated into hot asphalt. There seems to be no reason why such coating, if

a. b c.

FIG. 25.

a. b. c. d. e. f. g. h.

FIG. 26.

a. b. c. d. e.

FIG. 27.

a. b. c.

FIG. 28.

done with equal care, should wear off, when the pipe is in use, quicker from wrought-iron than from cast-iron pipes. It is a fact that all soil and waste pipes are coated after a little use with a peculiar, greasy slime, which tends to protect the pipe—a cast-iron as well as a wrought-iron pipe—against corrosion.

It occasionally happens in any system of soil or waste pipes that a length of pipe must be taken out and replaced, which can only be effected with plumbers' soil pipe by bursting a fitting. Such a result can also be attained in wrought-iron soil pipes by breaking a fitting; the new length can be inserted either by a flange-joint, or else by the use of a running thread and a lock-nut. It must be remembered that, in the case of plumber's soil pipe a heavy knock to break the pipe is likely to loosen many, if not all lead joints of the stack, while the screw-joints are not as easily affected.

It is true, to some extent, that cast-iron pipes are more easily and quickly cut for making connections without the necessity of great mechanical skill or any expensive tools. Wrought-iron pipes require heavy and costly stationary machines to which the pipe must be sent, or else slow-working and expensive hand-tools for cutting and threading. The lengths must be measured very accurately, and put together by skilled mechanics.

Some of the fittings for instance, Y branches for wrought-iron pipe are not so easily put in place on upright pipes in chaces, as the cast-iron fittings, but a skilled mechanic is generally able, with a little ingenuity, to overcome such difficulties."